

What Is Claimed Is:

1. A nonvolatile memory device, comprising:
a substrate of a semiconductor material having a first conductivity type;
a semiconductor block over said substrate and having a first sidewall and a second
sidewall opposite to each other and a top between said first sidewall and said
second sidewall, said semiconductor block including a first region having a
second conductivity type, a second region having said second conductivity type,
and a third region between said first region and said second region and having
said first conductivity type;
a folded floating gate over said third region of said semiconductor block, said folded
floating gate having a first section adjacent said first sidewall of said
semiconductor block, a second section adjacent said second sidewall of said
semiconductor block, and a third section adjacent said top of said semiconductor
block; and
a control gate disposed over said third section of said folded floating gate.
2. The nonvolatile memory device of claim 1, said semiconductor block having a height
between approximately 0.1 micrometer (μm) and approximately 1 μm and a width
between approximately 0.05 μm and approximately 0.8 μm .
3. The nonvolatile memory device of claim 1, said semiconductor block having a height
and a width, said height being greater than said width.
4. The nonvolatile memory device of claim 1, said semiconductor block having a
trapezoidal cross section.
5. The nonvolatile memory device of claim 1, further comprising an insulating layer
between said semiconductor block and said substrate.
6. The nonvolatile memory device of claim 1, said control gate including:

a polycrystalline silicon layer adjacent said third section of said folded floating gate;
and
a metalized polycrystalline silicon layer over said polycrystalline silicon layer.

7. The nonvolatile memory device of claim 1, further comprising:
a dielectric layer over said control gate; and
a tunneling gate over said dielectric layer.
8. The nonvolatile memory device of claim 1, said semiconductor block further including
a fourth region having said second conductivity type adjacent said second region, a fifth
region of said second conductivity type, and a sixth region of said first conductivity
type between said fourth region and said fifth region.
9. The nonvolatile memory device of claim 8, further comprising a second folded floating
gate over said sixth region of said semiconductor block, said second folded floating
gate having a first section adjacent said first sidewall of said semiconductor block, a
second section adjacent said second sidewall of said semiconductor block, and a third
section adjacent said top of said semiconductor block.
10. The nonvolatile memory device of claim 9, said control gate being further disposed
over said third section of said second folded floating gate.
11. The nonvolatile memory device of claim 10, further comprising:
a dielectric layer over said control gate;
a first tunneling gate over said dielectric layer and overlying said folded floating gate;
and
a second tunneling gate over said dielectric layer and overlying said second folded
floating gate.
12. The nonvolatile memory device of claim 10, further comprising:

a second semiconductor block over said substrate and having a first sidewall and a second sidewall opposite to each other and a top between said first sidewall and said second sidewall, said second semiconductor block including:

a first region having said second conductivity type, a second region having said second conductivity type, and a third region between said first region and said second region and having said first conductivity type; and

a fourth region having said second conductivity type adjacent said second region, a fifth region of said second conductivity type, and a sixth region of said first conductivity type between said fourth region and said fifth region;

a third folded floating gate over said third region of said second semiconductor block, said third folded floating gate having a first section adjacent said first sidewall of said second semiconductor block, a second section adjacent said second sidewall of said second semiconductor block, and a third section adjacent said top of said second semiconductor block;

a fourth folded floating gate over said sixth region of said second semiconductor block, said fourth folded floating gate having a first section adjacent said first sidewall of said second semiconductor block, a second section adjacent said second sidewall of said second semiconductor block, and a third section adjacent said top of said second semiconductor block; and

a second control gate disposed over said third section of said third folded floating gate and said third section of said fourth folded floating gate.

13. The nonvolatile memory device of claim 12, further comprising:

a dielectric layer over said control gate and said second control gate;

a first tunneling gate over said dielectric layer overlying said folded floating gate and said third folded floating gate; and

a second tunneling gate over said dielectric layer overlying said second folded floating gate and said fourth folded floating gate.

14. The nonvolatile memory device of claim 12, further comprising an insulating layer insulating said semiconductor block and said second semiconductor block from said substrate.
15. The nonvolatile memory device of claim 1, further comprising:
5 a second semiconductor block over said substrate and having a first sidewall and a second sidewall opposite to each other and a top between said first sidewall and said second sidewall, said second semiconductor block including a first region having said second conductivity type, a second region having said second conductivity type, and a third region between said first region and said second region and having said first conductivity type;
10 a second folded floating gate over said third region of said second semiconductor block, said second folded floating gate having a first section adjacent said first sidewall of said second semiconductor block, a second section adjacent said second sidewall of said second semiconductor block, and a third section adjacent said top of said second semiconductor block.
16. The nonvolatile memory device of claim 15, further comprising an insulating layer insulating said semiconductor block and said second semiconductor block from said substrate.
17. The nonvolatile memory device of claim 15, said control gate being further disposed over said third section of said second folded floating gate.
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18. The nonvolatile memory device of claim 17, further comprising:
a dielectric layer over said control gate;
a first tunneling gate over said dielectric layer overlying said folded floating gate; and
a second tunneling gate over said dielectric layer overlying said second folded floating gate.
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19. The nonvolatile memory device of claim 15, further comprising a second control gate disposed over said third section of said second folded floating gate.

20. The nonvolatile memory device of claim 19, further comprising:
a dielectric layer over said control gate and said second control gate; and
a tunneling gate over said dielectric layer overlying said folded floating gate and said
second folded floating gate.
- 5 21. A nonvolatile memory device, comprising:
a semiconductor substrate of a first conductivity type;
a plurality of semiconductor blocks over said substrate, each having a first sidewall and
a second sidewall, and a top between said first sidewall and said second sidewall,
each of said plurality of semiconductor blocks further including a first region of
10 a second conductivity type, a second region of said second conductivity type, and
a third region between said first region and said second region and of said first
conductivity type;
a plurality of folded floating gates, each over said third region of a corresponding one
of said plurality of semiconductor blocks and having a first section, a second
15 section, and a third section adjacent said first sidewall, said second sidewall, and
said top, respectively, of said corresponding semiconductor block; and
a plurality of control gates disposed over said plurality of folded floating gates.
22. The nonvolatile memory device of claim 21, wherein each of said semiconductor
blocks has a height between approximately 0.1 micrometer (μm) and approximately
20 $1\ \mu\text{m}$ and a width between approximately $0.05\ \mu\text{m}$ and approximately $0.8\ \mu\text{m}$.
23. The nonvolatile memory device of claim 21, wherein each of said semiconductor
blocks has a trapezoidal cross section.
24. The nonvolatile memory device of claim 21, further comprising an insulating layer
between said plurality of semiconductor blocks and said substrate.
- 25 25. The nonvolatile memory device of claim 21, further comprising a tunneling gate over
said plurality of control gates.

26. The nonvolatile memory device of claim 21, wherein each of said plurality of semiconductor blocks further includes a fourth region having said second conductivity type adjacent said second region, a fifth region of said second conductivity type, and a sixth region of said first conductivity type between said fourth region and said fifth region.
27. The nonvolatile memory device of claim 26, further comprising a second plurality of folded floating gates, each over said sixth region of said corresponding semiconductor block and having a first section, a second section, and a third section adjacent said first sidewall, said second sidewall, and said top respectively, of said corresponding semiconductor block.
28. The nonvolatile memory device of claim 27, wherein said plurality of control gates are further disposed over said third section of said second plurality of folded floating gates.
29. The nonvolatile memory device of claim 28, further comprising:
a first tunneling gate over said plurality of folded floating gates; and
a second tunneling gate over said second plurality of folded floating gates.
30. The nonvolatile memory device of claim 21, further comprising:
a second plurality of semiconductor blocks over said substrate, each including a first region of said second conductivity type, a second region of said second conductivity type, and a third region between said first region and said second region and of said first conductivity type;
a second plurality of folded floating gates, each over said third region of a corresponding one of said second plurality of semiconductor blocks; and
wherein said plurality of control gates are further disposed over said second plurality of folded floating gates.
31. A nonvolatile memory array, comprising:
a semiconductor substrate;

a plurality of semiconductor stripes over said substrate substantially parallel to one another, each having a first sidewall and a second sidewall, and a top between said first sidewall and said second sidewall, each of said plurality of stripes further including a plurality of sequentially arranged cells, each cell including a source region, a drain region, and a channel region there between;

a plurality of folded floating gates arranged in a plurality of rows and a plurality of columns, each over said channel region in a corresponding cell and having a first section, a second section, and a third section adjacent said first sidewall, said second sidewall, and said top, respectively, of a corresponding stripe; and

a plurality of control gates, each disposed over a row of said plurality of folded floating gates.

32. The nonvolatile memory array of claim 31, wherein each of said stripes has a height between approximately 0.1 micrometer (μm) and approximately 1 μm and a width between approximately 0.05 μm and approximately 0.8 μm .

33. The nonvolatile memory array of claim 31, wherein each of said stripes has a trapezoidal cross section.

34. The nonvolatile memory array of claim 31, further comprising an insulating layer between said plurality of stripes and said substrate.

35. The nonvolatile memory array of claim 31, further comprising a plurality tunneling gates over said plurality of control gates, each overlying a column of said plurality of folded floating gates.